# 3/2 NORMALLY CLOSED MODULE

## Background of the Invention

### Technical Field

The present invention is directed generally to modules, and, in particular, to 3/2 normally closed modules.

### Description of the Related Art

It is known to provide a module configured to selectively control fluid flow from a first port to a second port, as seen by reference to U.S. Patent No. 6,409,145 to Fong et al ("Fong"). Fong discloses an armature in combination with a valve seat to implement this fluid control. However, a problem generally encountered in the module field involves providing a module with a magnetic package strong enough to overcome the spring load required to maintain a tight seal. Such magnetic packages often impose both size and cost constraints which limit their use. Large magnetic packages also inflict significant mechanical stresses on a module that affect the module's long term performance. Another problem generally encountered in the module field involves providing a module where the component used to seal a valve, such as a poppet, is accurately machined to provide a tight seal. To accurately machine such a component is expensive, and the resulting component often does not provide a tight seal. Accordingly, there is a need in the art for providing a module that minimizes or eliminates one or more of the above-mentioned shortcomings.

## Summary of Invention

One object of the invention is to provide a solution to one or more of the above mentioned requirements. One advantage of the present invention is that its smaller size simplifies its installation and allows for its utilization in spatially constrained environments. Another advantage of the present invention is lower cost resulting from replacing expensive precision components, such as poppets, with inexpensive balls, such as ball bearings. Another advantage of the present invention is the enhanced sealing capability resulting from the use of ball bearings to seal the valve seats. Still another advantage of the present invention is that it is robust to

misalignment as well as errors in concentricity, and parallelism because the primary plate can be off-centered and/or tilted without affecting the performance of the armature and rod assembly.

In one aspect of the invention, a module includes a main body, a housing and a magnetically energizable coil. The main body includes a bore, an armature and a rod. The housing includes first and second valve seats and is configured to receive a first and second ball. The housing also includes a first, a second and a third port.

When the module is in an energized state, current flows through the coil, generating a magnetic field. The magnetic field forces the armature against the primary plate and pushes on the rod, which in turn, forces the first ball to engage the first valve seat. When the first ball engages the first valve seat, the first ball forces the second ball to disengage from the second valve seat. As a result, a fluid flow path is created between the first and second ports. When the module is in a de-energized state, a spring, disposed between the main body and the second ball, together with the hydrostatic pressure on the second port, forces the second ball to engage with the second valve seat. When the second ball engages the second valve seat, the second ball forces the first ball to disengage from the first valve seat. As a result, a fluid flow path is created between the first and third ports.

Other features, objects and advantages of the present invention will become apparent to one of ordinary skill in the art from the description that follows and may be realized by means of the instrumentalities and combinations particularly pointed out in the appended claims, taken in conjunction with the accompanying drawings.

## Brief Description of the Drawings

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a module having a main body and a housing;

Figure 2 is a cross-sectional view of a fluted well as viewed looking toward the main body, in accordance with the present invention; and

Figure 3 is a cross-sectional view of a fluted well as viewed looking toward the second ball, in accordance with the present invention;

Description of the Preferred Embodiments

Referring now to the drawings wherein like reference numerals are used to identify identical components in the various views, Figure 1 illustrates one embodiment of a module 10 having a main body 12 and a housing 14. Main body 12 is generally configured for selective control of fluid flow through housing 14. Housing 14 is generally configured to provide the combination of input/output ports to allow such fluid flow.

Main body 12 is centered about an axis 16. Main body 12 has a first bore 18 within which an armature 20 resides. Both bore 18 and armature 20 are centered about axis 16. Armature 20 is made from a ferromagnetic material. The shape of armature 20 can be altered to meet design requirements and thus is not limited to the exemplary shape illustrated in Figure 1. Armature 20 extends along axis 16 within bore 18. Main body 12 also has a coil 28 centered about axis 16. In the illustrated embodiment, when coil 28 is energized, an axial magnetic force acts on armature 20 in the direction of a primary plate 22. Primary plate 22 comprises a ferromagnetic material and is configured to establish flux paths for the magnetic flux generated by coil 28. Primary plate has a second bore 24 extending along axis 16. Main body 12 further includes a first spring 21 disposed between main body 12 and armature 20. Spring 21 is centered about axis 16 and preloads armature 20 with an axial force urging armature 20 toward primary plate 22. A rod 26, disposed between armature 20 and a first ball 38, discussed in further detail below, extends through second bore 24. Main body 12 further includes a frame 30. Frame 30 comprises a ferromagnetic material and is generally annular, thus extending substantially along the perimeter of main body 12. Frame 30 together with primary plate 22, and armature 20 act as flux paths for the magnetic flux generated by coil 28. Flanges 32 on frame 30 project radially inward toward axis 16. Flanges 32 are configured to affix housing 14 and main body 12.

Still in reference to Figure 1, housing 14 includes a well 34 centered about axis 16. In the illustrated embodiment, when coil 28 is energized, the magnetic field generated by coil 28 will force armature 20 against the primary plate 22, pushing

on the rod 26. Rod 26 is guided through an opening 36 exerts a force on a first ball 38. First ball 38 and a second ball 39 are axially movable within well 34. When displaced by rod 26, first ball 38 engages a first valve seat 40 within well 34, thereby causing second ball 39 to disengage from a second valve seat 46 within well 34. Once second ball 39 is disengaged from second valve seat 46, fluid flow is permitted between a first port 54 and a second port 56. Well 34 may also contain a set flutes 50, best shown in Figure 2 and Figure 3. Flutes 50 minimize non-axial movement of first ball 38 and second ball 39 within well 34 while allowing fluid flow past the balls. The shape of flutes 50 can vary depending upon design requirements, thus the invention is not limited to the exemplary shapes of flutes 50 as depicted in Figures 2 and 3. A second spring 48 links second ball 39 to main body 12. Second spring 48 slightly preloads second ball 39, causing it to remain engaged with second valve seat 46 until module 10 is energized.

Referring again to Figure 1, when module 10 is in an energized state, current supplied from an external source, not shown, flows through coil 28. This current flow induces a magnetic field, which is mostly contained within module 10 by primary plate 22, armature 20 and frame 30. As armature 20 moves toward primary plate 22, it exerts a force on rod 26 as it slides axially through opening 36. Rod 26 exerts a force on first ball 38, forcing first ball 38 to engage first valve seat 40 and compressing second spring 48. Once first ball 38 engages first valve seat 40, the preload supplied by second spring 48, which forces second ball 39 to engage with second valve seat 46 while module 10 is in a de-energized state, will be overcome. Hence, second ball 39 is disengaged from second valve seat 46, thereby allowing fluid to flow between first port 54 and second port 56. In one embodiment of the invention, first port 54 can be a control port that directs fluid flow, while second port 56 can supply fluids from external sources not shown to module 10.

When module 10 is in a de-energized state, no current flows through coil 28. Because no magnetic flux is present to force armature 20 to move toward primary plate 22, there is no force present to overcome the preload supplied by second spring 48. Thus, second ball 39 is forced by preloaded second spring 48 to engage with second valve seat 46. First ball 38 is forced to disengage from first valve seat 40. As first ball 38 is disengaged from first valve seat 40, a fluid flow path is created between first port 54 and a third port 58. In one embodiment of the invention, third

port 58 can exhaust fluids from module 10. The use of the nomenclature “3/2 module” indicates that the module has three ports that permit two paths of fluid flow. For example, when module 10 is in an energized state, fluid flow is permitted between first port 54 and second port 56, constituting one path for fluid flow. When module 10 is in a de-energized state, fluid flow is permitted between first port 54 and third port 58, constituting a second path for fluid to flow.

From the foregoing, it can be seen that a new and improved module has been brought to the art. It is to be understood that the preceding description of the preferred embodiments is merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention. Other arrangements would be evident to those skilled in the art without departing from the scope of the invention as defined by the following claims.